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Choice of glues for wood

This Digest offers guidance on the correct choice of glue for structural and semi-structural applications, having regard to the circumstances under which the joint will be employed and the conditions to which it is exposed. It is not possible in a Digest to make a complete catalogue of the suitability of all adhesives for all possible conditions of use, but further advice can be obtained from the Princes Risborough Laboratory; assurance of the suitability of particular grades of adhesive for a defined purpose should always be obtained from the glue manufacturer.

The use of glues in the fabrication of timber structures and semi-structural components offers a neat and efficient method of bonding together the separate pieces of wood, or of board products such as plywood and fibreboard, which comprise the finished product. The glue bond attained must meet the strength requirements for the structure as a whole and this bond must be essentially unaffected by the conditions to which it will be exposed throughout its life. Developments in the adhesives industry have led to the production of a wide range of glues suitable for different purposes and it is necessary that the adhesive chosen should be fit for the task it must perform. This Digest outlines the range of conditions which such joints may encounter in service and makes recommendations as to the types of adhesive which must be employed to give optimum results.

No attempt is made to discuss in detail such matters as wood surface preparation, adhesive application or bond-forming techniques, which are described elsewhere.[1] It should be emphasised, also, that the Digest is only concerned with the glue and its durability; in adverse conditions of use, the wooden elements comprising the joint, if not of durable species, may require treatment with a wood preservative.

Conditions of exposure

Glued joints in buildings may meet a wide variety of exposure conditions, ranging from sheltered situations indoors to full outdoor exposure, or to aggressive chemical environments. These conditions may be classified under the five headings used in Table 1, which also gives examples typical of each exposure class.

Durability of glues

Adhesive formulations exhibit a wide variation in their resistance to degradation by such agents as moisture, heat and chemicals. In general, the recent synthetic products are more durable than the older ones based on natural materials, eg fish and animal glues and casein adhesives but even within the synthetic group differences are evident. In British Standards concerned with wood products bonded with synthetic resin adhesives, it is current practice to classify the durability of the joint in terms of its resistance to the conditions to which it will be exposed. Long-term exposure trials of joints have been carried out at PRL over the years and the results of these trials have been correlated with the performance in the laboratory of similar joints which have been subjected to immersion in cold, hot or boiling water. A four-group classification for the durability of glues has been evolved.[2]

Type WBP *Weather and boil proof* Adhesives of the type which by systematic tests and by their records in service over many years have been proved to make glue lines highly resistant to weather, micro-organisms, moisture and heat. Only adhesives of the phenol-formaldehide (PF) and resorcinol-formaldehyde (RF) types, and mixtures of these, can satisfy this requirement.

Type BR *Boil resistant* Glue lines formed from these adhesives have good resistance to weather but fail under very prolonged exposure that WBP adhesives will survive. Adhesives of the melamine/urea-formaldehide (MF/UF) types can satisfy this requirement.

Type MR *Moisture resistant and moderately weather resistant* Glue lines formed from these adhesives will survive full exposure to weather for only a few years and degrade in hot wet conditions. Adhesives of the urea-formaldehyde (UF) type can satisfy this requirement.

Type INT *Interior* These will not survive exposure to weather and are unsuitable for damp interior conditions. Adhesives of the urea-formaldehyde (UF) and casein types are normally satisfactory.

Choice of adhesive

As the adhesives under consideration are for use mainly in structural and semi-structural components, an expected life of fifty years or so is usually required. It must be appreciated, however, that experience of performance over this period is not yet available for any of these glues. Nevertheless, recommendations for currently available adhesives can be based on the performance of similar types over the past 20 to 25 years[3] coupled with a knowledge of their formulations. In Table 1, the adhesives considered suitable for each type of exposure condition are classified in relation to their durability type.

The extremes of exposure conditions (exterior high hazard and interior low hazard) present little difficulty in relation to choice of adhesive for glued products. For full exposure to the weather, an adhesive of type WBP is essential (*see* note page 4 on resorcinol shortage). For normal interior conditions, obviously resorcinol and phenol-formaldehyde resins are suitable but, in general, casein and urea-formaldehyde glues are also adequate. In addition, melamine/urea-formaldehyde formulations are satisfactory, though their better resistance to moisture than the straight urea-formaldehydes is not strictly necessary for this situation.

Between the extremes of total exposure to weather and complete protection indoors lies a broad band of conditions in which glued structures and components are used. Here the choice of adhesive may be more difficult, for instance, an adhesive with only limited durability may prove sufficient even under severe conditions for a product with a short life expectancy.

For very damp interior conditions, as in swimming bath structures and some farm buildings, only a glue of type WBP can be recommended. However, many farm buildings are heated and, if adequately ventilated, can be classified as 'interior'; for these, urea-formaldehyde and casein glues are considered adequate.

There is evidence that some of the urea-formaldehyde adhesives in use twenty-five years ago have lost strength after ten years of indoor conditions, though other brands have retained their original strength after twenty-five years. Assurance is given by the adhesive manufacturers that the improvements in formulation and setting mechanisms of currently available urea-formaldehyde glues should result in improved long-term performance. For structural use, the gap-filling type conforming to the requirements of BS 1204 : 1964 : Part 1 is recommended in preference to the close-contact type. Caseins should meet the requirements for type A of BS 1444 : 1970[4] and should contain fungicides and insecticides. Users of any of these glues who require a high strength to be maintained for a long period must consult the adhesive manufacturers and obtain their assurance as to the suitability of a particular grade.

It should be pointed out that prefabricated structures for interior use may be exposed, during the initial stages of construction of a building, to extremes of climatic conditions and precautions should be taken to protect them, particularly if casein has been used.

Glued members in ventilated roof spaces are subjected to cyclical conditions of temperature and humidity and although a manufacturer who maintains a one-glue system might use a resorcinol (RF) adhesive, it is considered that a melamine/urea-formaldehyde (MF/UF) would be satisfactory in terms of durability.

Container floors should be mentioned. These may be subjected to a wide range of conditions, often severe, but have a life expectancy of no more than about ten years so that the use of the less durable MF/UF in place of the RF or PF types is justified.

Although painting and careful maintenance of the paint coating throughout the life of the structure will usually enhance the performance of joints made with the less durable glues, any small imperfection in the paint film will allow the entry of water which could cause breakdown of the glueline. As damage to protective coatings can easily be incurred in service, the use of the less durable glues in severe conditions of exposure, and reliance on paint coatings to protect them, is dangerous and is not recommended.

Gluing wood at the higher moisture contents

Experience has shown that in gluing wood the optimum results are obtained when timber is kiln-dry (12 to 15 per cent moisture content) at the time of gluing. However, in some situations, especially where the moisture content of the wood in service will exceed these figures, it would clearly be advantageous to glue wood at a higher moisture content. It has been shown[5] that satisfactory joints can be made with air-dry timber (18 to 22 per cent moisture content) using any of the common wood glues, but at higher moisture contents, up to say 26 per cent, only RF or RF/PF glues can be recommended.

Table 1 Choice of adhesives for different applications

Exposure category	Exposure conditions	Examples	Recommended adhesive (see key)	Performance type (see p 1)	BS reference
Exterior					
High hazard[1]	Full exposure to weather	Marine and other exterior structures. Exterior components or assemblies where the glueline is exposed to the weather	RF	WBP	BS 1204 : 1964 : Part 1
			RF/PF	WBP	
			PF (cold-setting)	WBP	
Low hazard[2]	Exposed to weather but protected from sun and rain	Inside the roofs of open sheds and porches	RF; RF/PF; PF	WBP	BS 1204 : 1964 : Part 1
			MF/UF[3]	BR	
Interior					
High hazard	In closed buildings with warm and damp conditions where a moisture content of 18% is exceeded and where the glueline temperature can exceed 50° C	Laundries; roof spaces	RF; RF/PF; PF	WBP	BS 1204 : 1964 : Part 1
			MF/UF[3]	BR	
Low hazard	Heated and ventilated buildings where the moisture content of the wood will not exceed 18% and the glueline will remain below 50° C	Inside dwelling houses, heated buildings, halls and churches	RF; RF/PF; PF	WBP	BS 1204 : 1964 : Part 1
			MF/UF[3]	BR	
			UF[4]	MR	
			Casein		BS 1444 : 1970 : (type A)
Special	Chemically-polluted atmospheres	Structures in the neighbourhood of chemical plants or associated with the manufacture of electrical batteries, Dyeworks. Swimming baths	RF; RF/PF; PF	WBP	BS 1204 : 1964 : Part 1

Key

MF/UF melamine/urea-formaldehyde
PF phenol-formaldehyde
RF resorcinol-formaldehyde
RF/PF resorcinol/phenol formaldehyde
UF urea-formaldehyde

Notes

1 If the expected life of the structure is short, eg 10 years, MF/UF types are considered adequate.

2 It is understood from the glue manufacturers that improvements in the formulation of currently available UF glues should permit their use in the 'exterior low hazard' category. In such cases, the assurance of the glue manufacturers should be obtained of their suitability for the particular use contemplated.

3 Few data are available on the long-term performance of cold-setting MF/UF glues but assurance is given by the glue manufacturers that they are suitable for the categories indicated.

4 An assurance should be sought from the glue manufacturer that a particular formulation is suitable for the service conditions and for the length of life envisaged.

Gluing wood treated with preservatives or fire-retardants

The interaction of glues with preservatives varies with the nature of the preservative employed.[5,6] The presence in the wood of such preservatives as tributyltin oxide or pentachlorophenol has little adverse effect on bond quality, irrespective of the glue employed, but as increasing amounts of wax or other additives are introduced into the formulations to provide a degree of water-repellency, deterioration in the performance of many adhesives becomes evident; at high additive contents, RF and RF/PF glue types give the best results. The chemical interaction of RF and PF types with creosote or water-borne preservatives based on copper/chrome/arsenate or boron is usually small. UF types can be considerably affected by creosote, however, and conflicting results have been obtained with copper/chrome/arsenate.

PF, RF, or casein glues are generally unsuitable for the gluing of wood treated with inorganic fire-retardants and bonds of only poor quality are obtained. UF glues, however, are normally suitable for this purpose, provided that the wood is dry at the

time of assembly. A higher degree of moisture-resistance in use can be conferred by using MF/UF formulations and this may be important in situations where the assembly is likely to be exposed to adverse humidity conditions.

In the gluing of preservative or fire-retardant treated wood, the performance of the glue can be dependent not only on the type of adhesive but also on the brand. Thus, the glue manufacturer should always be consulted so as to ensure that the brand used is compatible with the wood treatments employed.

Gluing 'difficult' woods

Most woods in their natural state are reasonably easy to glue. Dense and heavy species are always more difficult than those of light or moderate weight but even some of the latter are troublesome. These are mostly the species that contain resins or oils which form a surface to which glue does not readily adhere; performance can be improved by removing the contaminated surface film and gluing up as soon as possible. When dealing with unusual or potentially troublesome timber species, advice on their gluing should be sought from the glue manufacturers or from Princes Risborough Laboratory.

WBP glues: the resorcinol shortage

A world shortage of resorcinol has presented the manufacturers of RF adhesives with the problem of supplying suitable alternatives. Users, such as component manufacturers, are faced in their turn with the responsibility of ensuring that their products continue to satisfy the durability requirements hitherto met by the use of RF adhesives. The resorcinol shortage is not likely to be relieved in the immediate future and 'pure' RF resins will be more difficult to obtain than in the past. However, RF/PF resins have been produced which meet the requirements.

Cold-setting PF resins have also been developed and can be made available. The use of this type of glue calls for some modifications to production techniques and greater care and attention to detail in handling and use.

References

1 *Requirements and properties of adhesives for wood* PRL Bulletin No 20 : 1971 London HMSO

2 BS 1204 : 1964 *Specification for synthetic resin adhesives* Part 1: *Gap-filling adhesives* London BSI

3 *The efficiency of adhesives for wood* PRL Bulletin No 38 : 1968 London HMSO (*now out of print*)

4 BS 1444 : 1970 *Cold-setting casein adhesive powders for wood* London BSI

5 R A Laidlaw and B H Paxton *The effect of moisture content and wood preservatives on the assembly gluing of timber* BRE Current Paper CP 54/74

6 *Gluing preservative-treated wood* PRL Technical Note No 31: 1968

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